Results of Investigation by Commission Staff into A Northern Utilities, Inc. Gas Pipeline Failure Main Street, Lewiston, Maine January 12, 2004

Docket No. 2004 - 49

Maine Public Utilities Commission

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A Northern Utilities, Inc. Gas Pipeline Failure
Main Street, Lewiston, Maine
On January 12, 2004

Summary

On January 12, 2004 at approximately 4:00 P.M. an explosion occurred at 95 Main Street, Lewiston, Maine. This investigation was initiated to determine if Northern Utilities, Inc. complied with applicable gas safety regulations and to determine the cause of the pipe failure.

It found that Northern did comply with State and Federal gas pipeline regulations as they pertain to the operation and maintenance of the six- inch cast iron pipe under Main Street. However, several recommendations are made that would improve Northern's functions.

The failure of the pipe occurred in two stages. The bottom third was fractured approximately six months prior to the explosion and resulted from subsidence of the soil under the pipe. The external loads above the pipe were no longer offset by the support system under it. The remainder of the pipe was fractured by the underground shock wave caused by the explosion.

Introduction

This report chronicles the findings of the an investigation to determine the cause of the failure of a six inch cast iron natural gas pipeline located under Main Street, Lewiston, Maine. The investigation was initiated by the Maine Public Utilities Commission (Commission) pursuant to Chapter 130, Section 4(2) of its rules. By agreement, the Commission is a certified agency of the U. S. Department of Transportation, Office of Pipeline Safety and is responsible for confirming compliance with federal laws and regulations that pertain to the safe operation of intrastate gas facilities. As such, the Commission also conducted this investigation as required by Title 49 USC Chapter 601.

The Commission staff (staff) wishes to acknowledge the assistance and advise of C. J. Behounek, PE, former U. S. Department of Transportation pipeline inspector and Veda-Anne Ulcickas and James J. Scutti with Massachusetts Materials Research, Inc. The cooperation of Northern Utilities, Inc. (Northern) personnel and its' contractor for removal of the failed pipeline, New England Utility Constructors, Inc., contributed to the completeness of this report. We also appreciated the assistance of Kenneth L. Grimes, CFI with the Office of the State Fire Marshal and Chief Michel Lajoie of the Lewiston Fire Department.

Background

On January 12, 2004 at approximately 4:00 P.M., an explosion on Main Street, Lewiston was reported to employees of Northern who were at their office in the city. The location of the explosion was later determined to be 95 Main Street, a vacant four-story wood structure known as the former Holly Hotel. An adjacent one-story building, Lewiston Radiator Shop, was also heavily damaged and later demolished.

Assuming this was a gas-related incident, Northern immediately responded to the scene and instituted its emergency procedures to prevent further destruction and potential injuries. Northern searched for a possible gas leak at the explosion site, in the vicinity of its six-inch gas main under Main Street, in adjacent buildings and in utility manholes in the paved roadway. By 5:20 P.M., having not found any indication that gas was leaking, Northern notified the Lewiston Fire Department it was leaving the scene of the incident to return to their office.

At approximately 6:00 P.M., Northern was informed that the debris pile at the explosion site had ignited and was on fire. Northern again responded to the incident site and performed more leak surveys. At their Lincoln Street station, they also confirmed that the gas contained sufficient odorant to assist in the detection of a leak. After completing additional surveys and not finding leaking gas, they moved to Lincoln and Main St. to standby near to the fire.

A Lewiston firefighter informed Northern that a gas odor was noticed at 6:40 P.M. near the canal at a higher elevation and north of the former hotel. Northern resurveyed the buildings and manholes in this area and found gas above the explosive limit in telephone manhole #2 (Exhibit 1). All manholes were opened and allowed to ventilate. A comprehensive search was initiated for the source of gas. Continued surveillance of adjacent buildings and area manholes was begun and maintained at one-half hour intervals (Exhibit 2). At 11:30 P.M., Northern began drilling holes through the pavement and frozen soil above the gas main. This attempt to locate the source of the leak was suspended from 2:00 A.M. to 9:30 A.M., January 13, 2004 because the State Fire Marshal's Office ordered that the building debris obstructing access to the main not be removed from the street until it could be examined in daylight.

Proceeding south down Main Street, holes were drilled from 9:30 A.M. to 2:25 P.M. At this time, a bar hole reading of 100% gas to air was discovered in front of the former hotel. Excavation was begun but did not result in locating the leak. After further investigation, a second excavation approximately 15' further south than the first hole resulted in locating a crack in the six inch cast iron main at approximately 10:00 P.M. The break was a full circumferential fracture located 22 feet east of the front foundation wall of the demolished hotel and in line with its south wall. The main was installed in 1895 and found to be 4'-3" below the street surface. The ground was frozen to a depth of 2'-9". A detailed chronology of events is included as Exhibit 3.

On January 13, 2004, after searching, removing and examining debris from the basement of the former hotel, the Lewiston Fire Chief and the State Fire Marshal's Office determined that the cause of the explosion was natural gas.

Investigation

The Commission's responsibilities for investigating a natural gas incident are two fold:

1. To determine if Northern complied with all state and federal gas safety regulations and;

2. To identify the cause of the pipeline failure.

This report is structured accordingly. Part A comprises the results of a comprehensive evaluation of Northern's operating and maintenance practices as they pertain to the failed pipeline. Part B is an analysis of the metallurgy and physical condition of a six-foot segment of the six-inch cast iron pipe removed from Main Street that included the fracture. This examination was structured to answer sixteen questions developed by the staff to facilitate determination of the dynamics that caused the pipe fracture.

Part A – Regulatory Compliance

Chapter 420 of the Commission's rules and Title 49, Part 192 of the Code of Federal Regulations regulate the operational integrity and safety of natural gas distribution lines. As they relate to this incident, a detailed examination of Northern's operating and maintenance procedures and required documentation confirming compliance with these procedures and the regulations was performed. In addition, facility and material records were reviewed and analyzed. The exhibits associated with Part A detail the areas examined.

Part B – Pipe Failure Analysis

The testing and detailed analysis to determine the cause of the pipe failure was performed by Massachusetts Materials Research, Inc (MRR), an independent laboratory selected for its experience in analyzing cast iron failures. The firm was selected in concurrence with, and the testing witnessed by, representatives of the owner of the demolished buildings and Northern. The results of the MRR investigation and related exhibits are presented in this part.

Findings

Northern did not violate any State or Federal gas safety regulation that could be attributable to causing this incident. However, there were several observations made which lead to the recommendations below.

In regard to the cause of the pipe failure, the results of the testing protocols provided sufficient evidence that the full circumferential fracture of the

6-inch cast iron pipe occurred in two stages. The first stage occurred in the bottom third of the pipe (4-8 o'clock). Corrosion products on the fracture surface indicated that the fracture existed approximately six months before the explosion and was most likely caused by external loads on the upper half of the pipe when it was not supported on the bottom due to subsidence of the soil under the main. The fracture happened directly over a water line crossing perpendicular to the gas main. The water line was installed many years after the gas main. Earthquakes were felt in the Lewiston area in July and August 2003. Backfilled soil around the water line could have settled as a result. Another possibility is that a break in the water main resulted in subsidence. Although it could not be proven, if this break occurred six months before the event it could also have caused the support system for the gas line to be undermined. Structural calculations included in Part A demonstrate that a settlement of approximately one-quarter of an inch could have resulted in the fracture of a pipe with the same metallurgical and environmental attributes as the subject pipe.

The second stage of the fracture (8-4 o'clock) was much newer in appearance. This section of the fracture face's metallurgical characteristics was consistent with having been cause by the underground shock wave resulting from the explosion.

Since the gas main operates at or less than 0.5 psi and the pipe was only partially cracked, a small volume of gas was leaking before the explosion. Coupled with a frost cap above the main, the gas could only move horizontally making discovery of the leak difficult. This allowed buildings to be vulnerable since service lines to them provide low resistance pathways for the gas to follow. The former hotel had two inactive gas services that penetrated the building foundation. Both were disconnected at the main and had capped ends. No gas leaks were detected at the plugs on the main.

Investigations of similar gas incidents found that it is not unusual for gas not to be detected after an explosion. The consensus is that the gas is consumed in the explosion and with a low pressure main and obstructed pathways, time is required to rebuild detectable levels.

Graphitic corrosion was found throughout the pipe segment. Numerous "pin hole" leaks were observed during testing as well as an area of 98% wall loss at 11'oclock on the fracture surface that did not leak. Neither was considered a factor in this failure. When gas escapes through very small holes, it dehydrates the soil adjacent to the pipe because the moisture content of the gas is lower than the dirt. The "cemented" soil forms a barrier on the pipe surface that greatly diminishes the ability of the gas to escape in sufficient quantities to cause an explosion.

Recommendations

These recommendations are included with the intent of improving Northern's performance of its obligation to protect the public's safety. They are discussed in more detail in the relevant sections of Part A.

1. Increase the training intensity of all Northern field personnel to ensure that all Company operating and maintenance procedures are carried out.

2. Develop a “Patrolling” training plan in accordance with the recommendations of ANSI B31.8, the Gas Pipeline Technical Committee Guidelines, and Federal Office of Pipeline Safety interpretations.

3. Revise the appropriate existing Company procedures to further clarify what is to patrolled, what is to be observed, what is to be reported, who is responsible for carrying out the patrols and what is the follow-up procedure.

4. Prepare a new Company procedure that explicitly spells out how pressure-recording charts are to be managed. This should include documentation of discontinuities, use of the appropriate chart for the recorder and changing the chart at the appropriate time.

5. Develop a more comprehensive public education program, particularly with the Lewiston Fire, Police and Public Works Departments.

6. Train field personnel to understand, test and recognize graphitization.

7. Review and emphasize Company procedures for maintaining and organizing material and facility records.